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(54) Transformer apparatus with rectifiers

(57) A transformer apparatus for use with a welding gun 60 includes four transformer/rectifier assemblies 15a, 15b, 15c, 15d each comprising a transformer 16a, 16b, 16c, 16d including a secondary winding and a rectifier, a terminal plate 30a, 30b, 30c, 30d connected to the secondary winding 22a through the rectifier 28a, and a centre tap terminal plate 38a connected to an intermediate portion of the secondary winding 22a. The terminal plate 30a and the centre tap terminal plate 38a are disposed on one side of the transformer, and the transformers of the transformer/rectifier assemblies are disposed side by side. The terminal plates of the transformer/rectifier assemblies are disposed closely to each other in confronting relation. First and second conductive bodies 42, 44 interconnect the terminal plates and the center tap terminal plates of the transformer/rectifier assemblies.

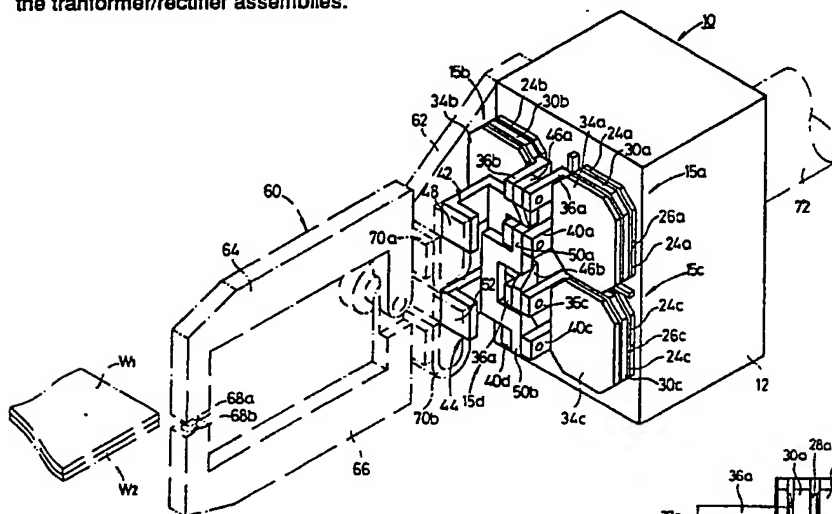


FIG.1

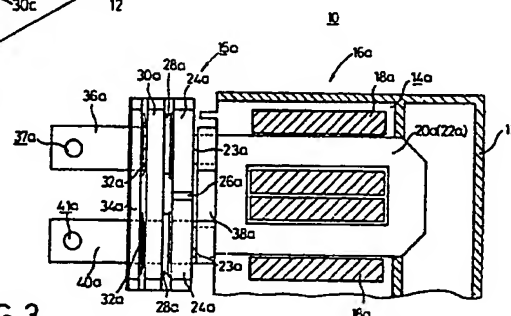


FIG.3

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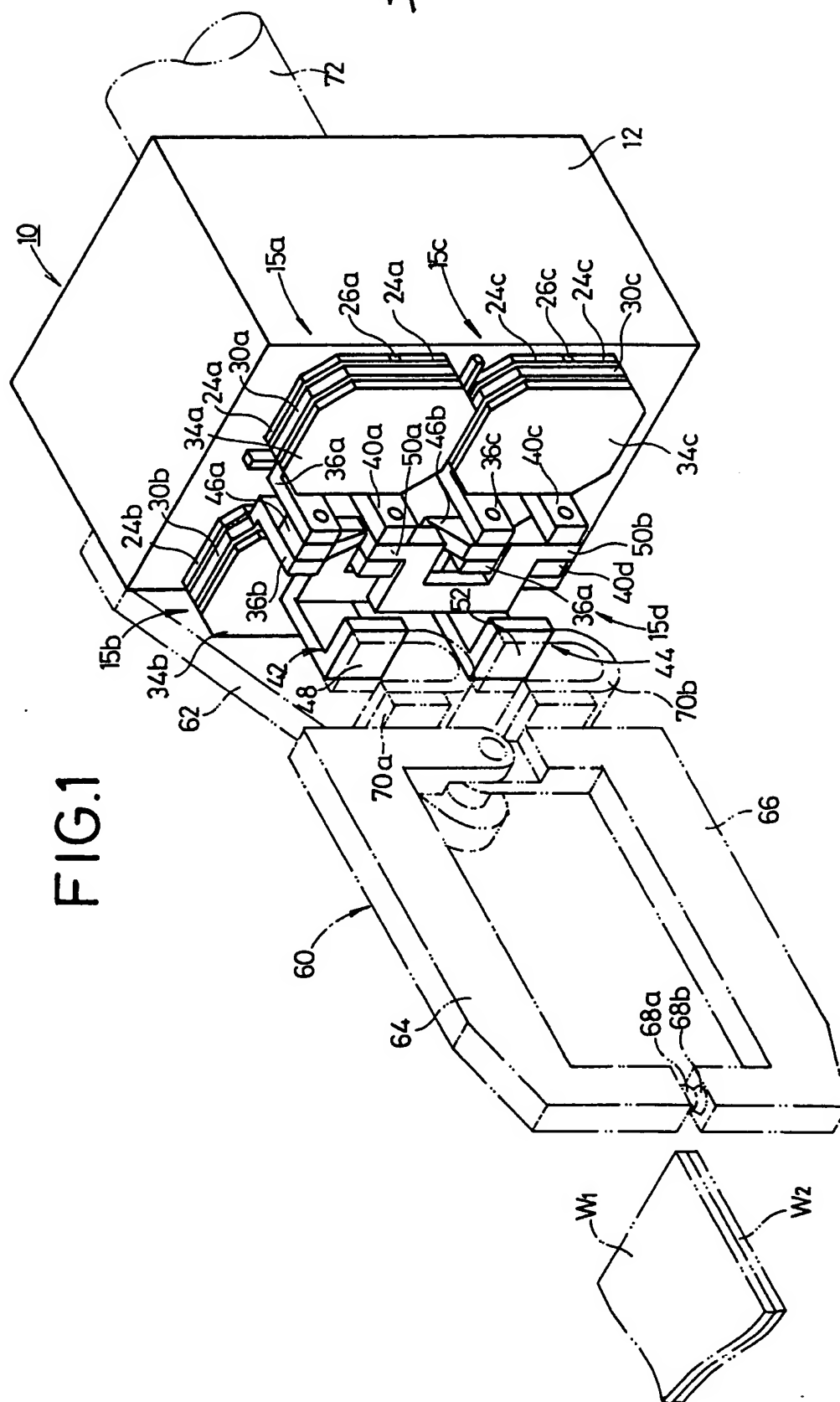
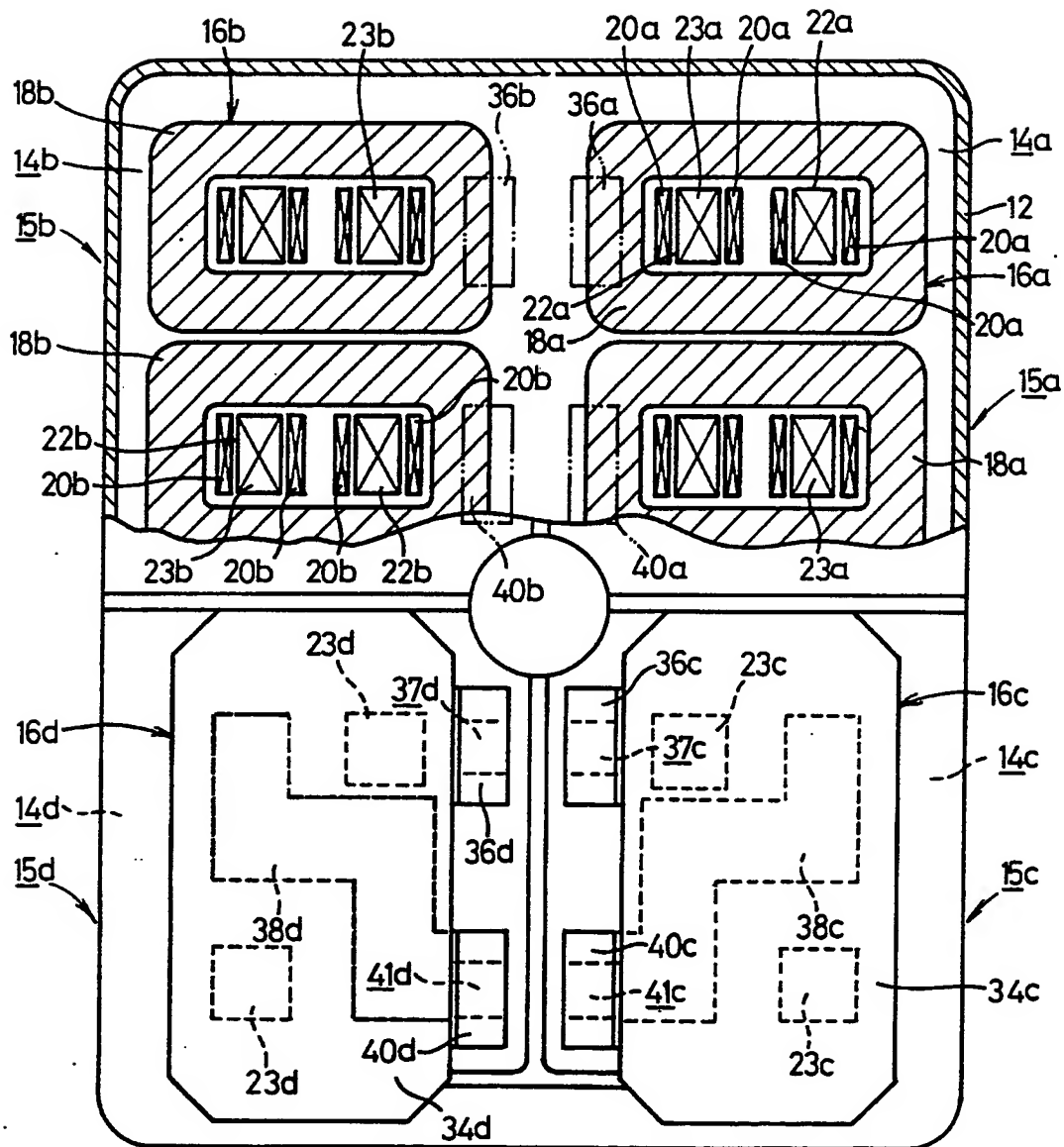


FIG. 2

10

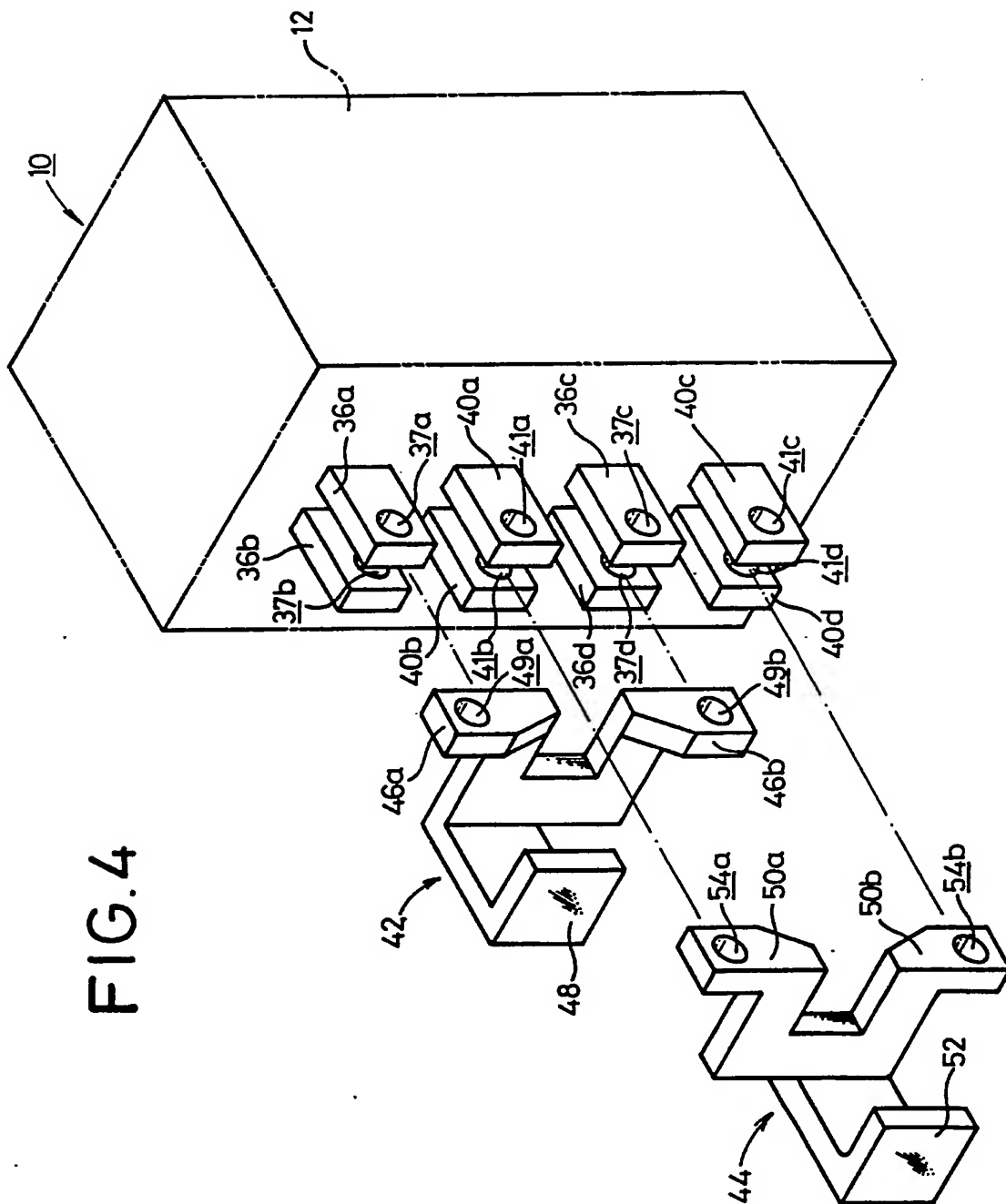


C

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FIG. 4



C

6/9

FIG. 5

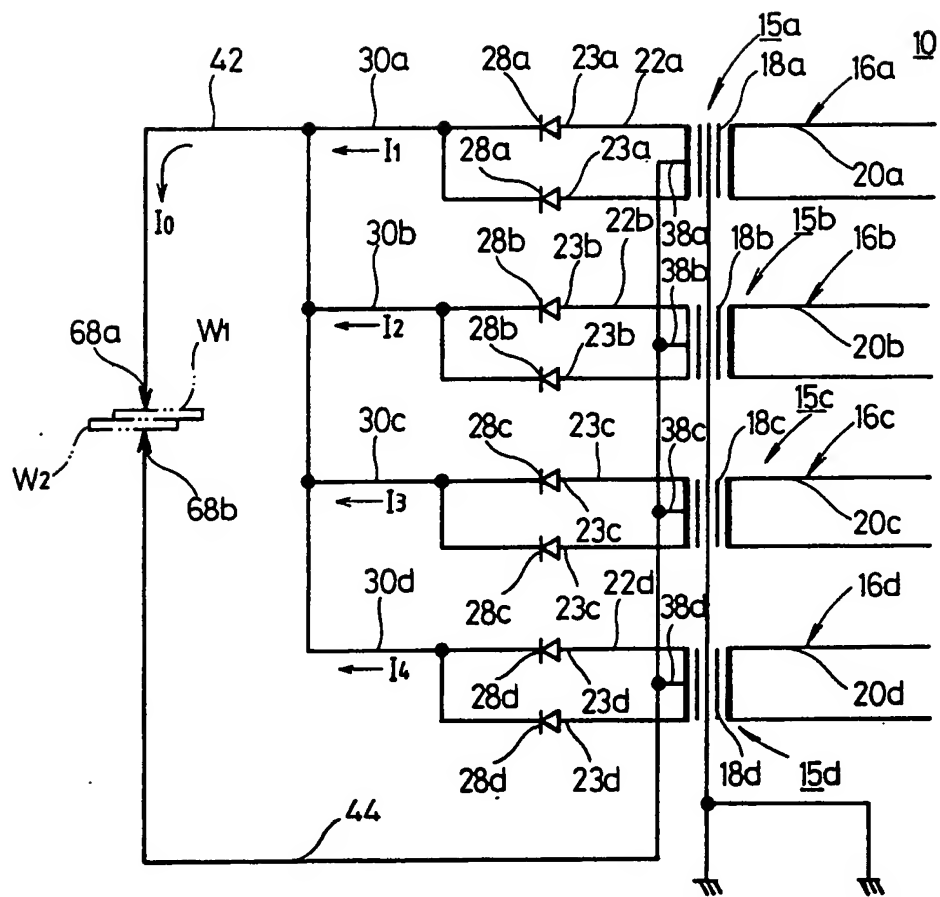
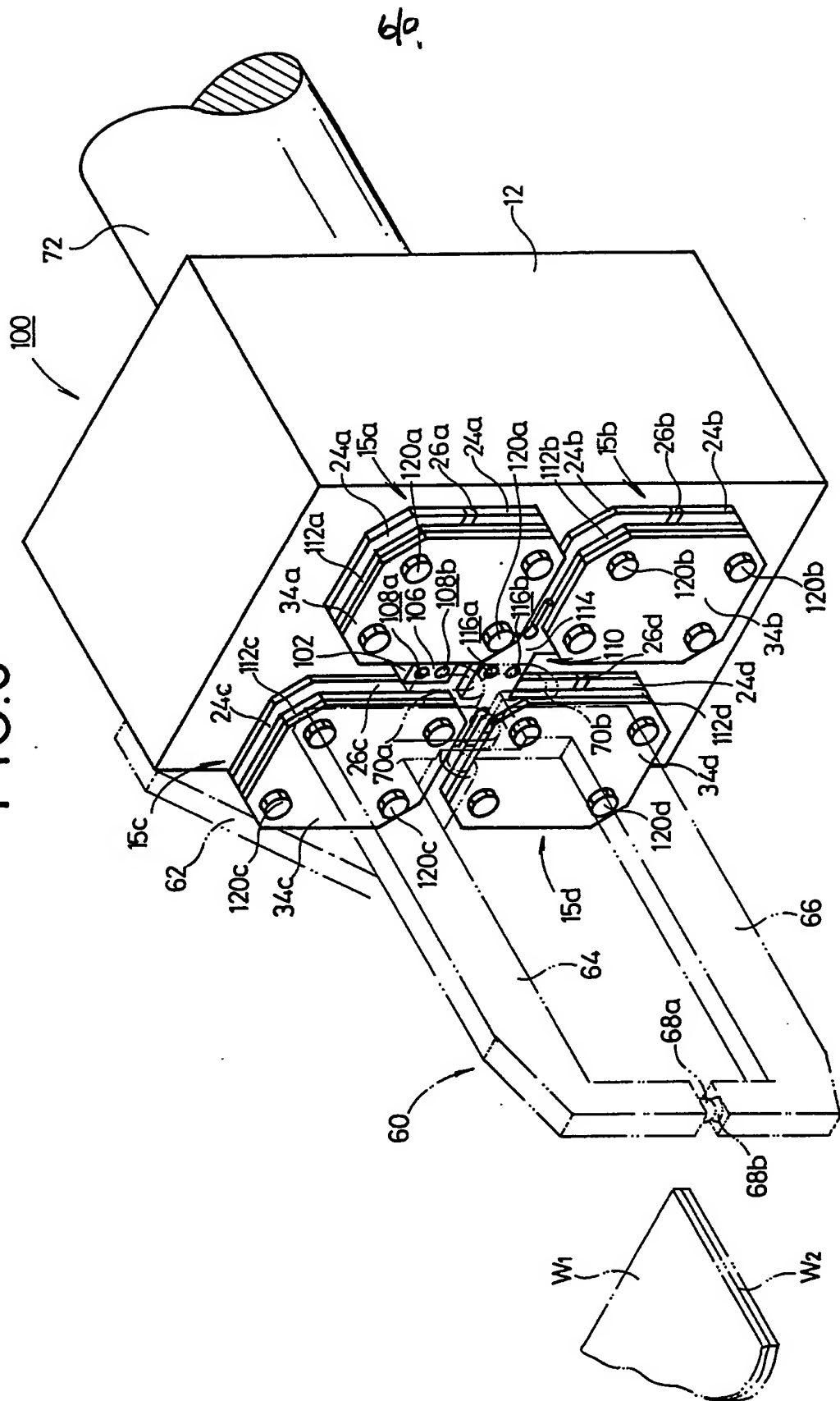
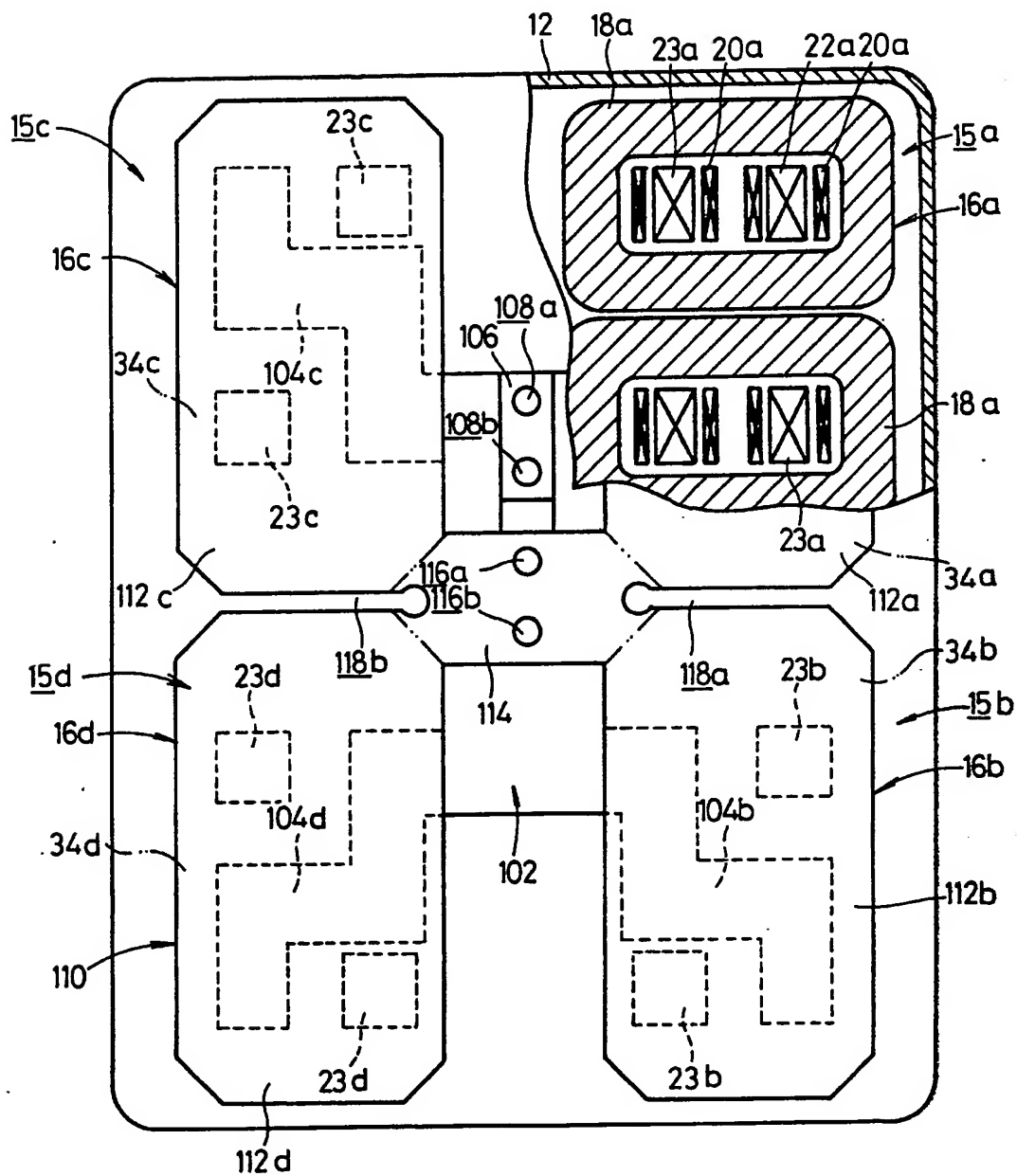


FIG.6



100



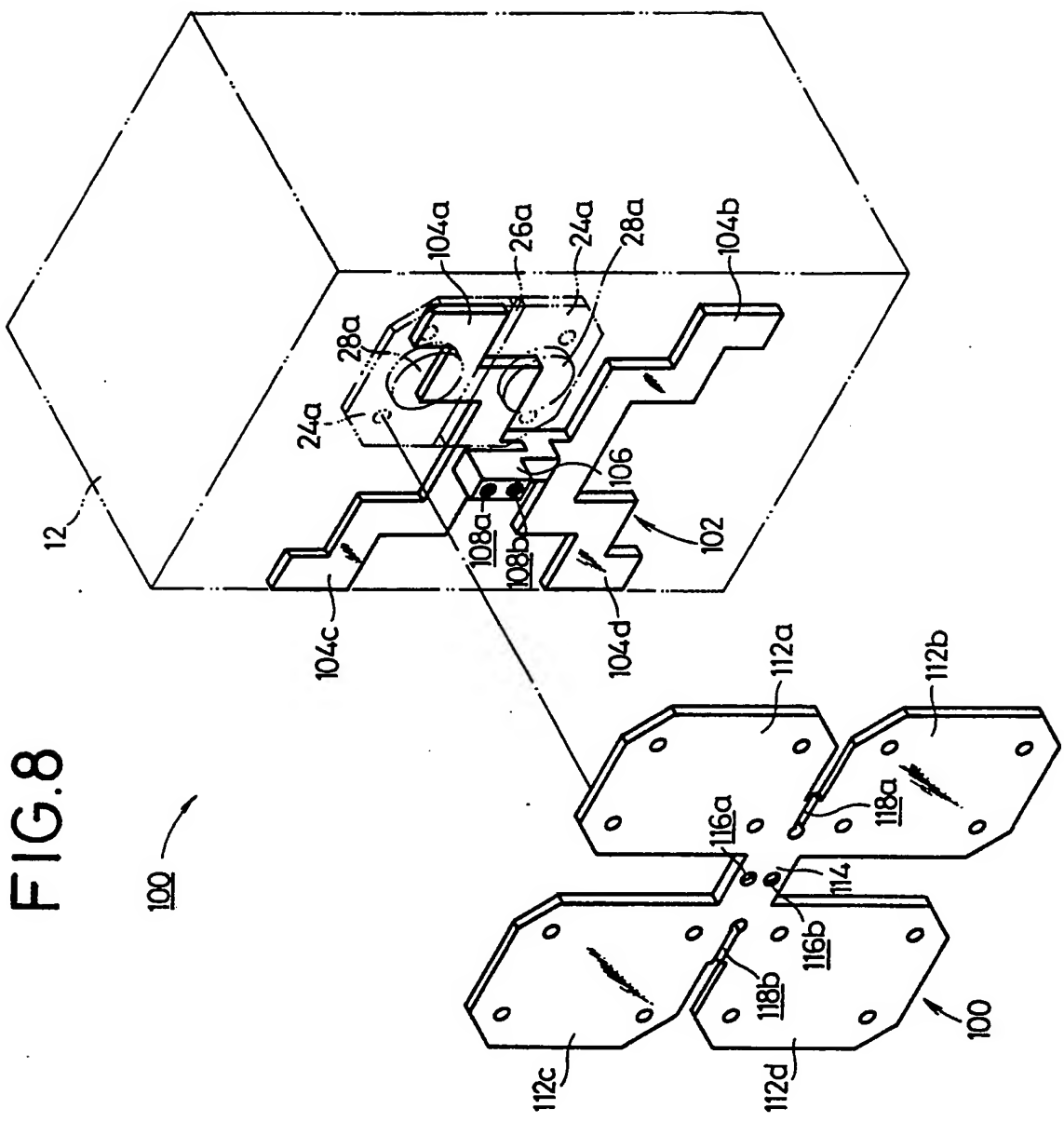
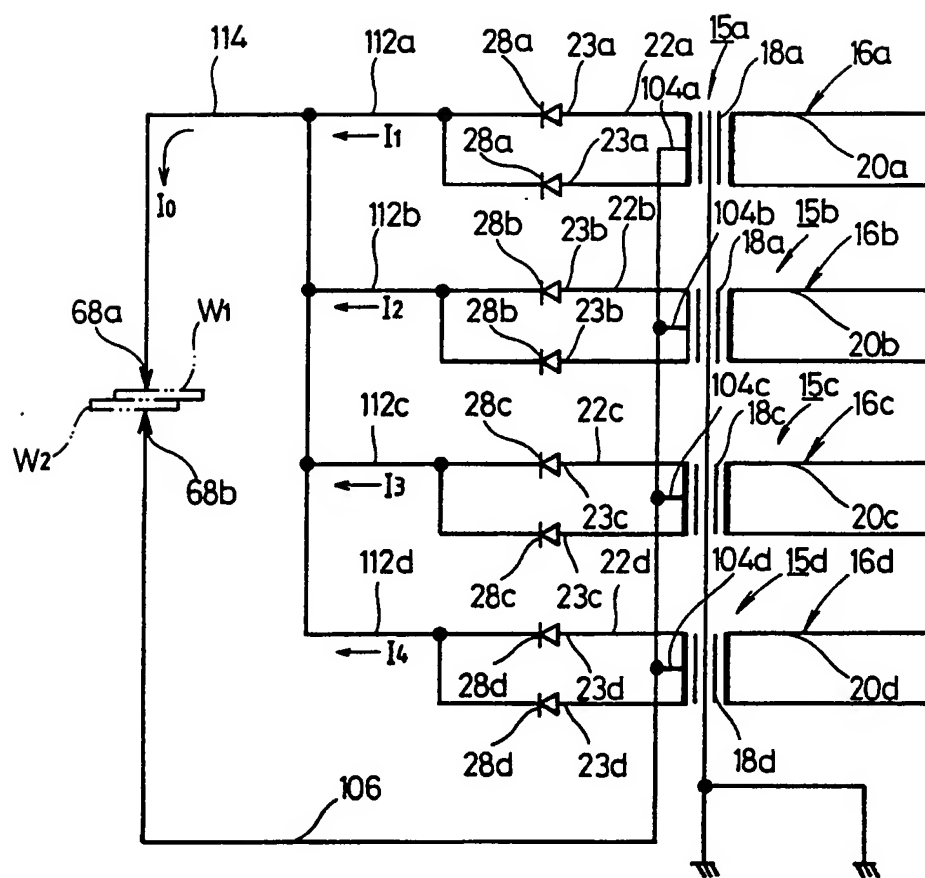


FIG. 9

100



TRANSFORMER APPARATUS WITH RECTIFIERS

The present invention relates to a transformer apparatus with rectifiers, and more particularly to a transformer apparatus comprising two or more transformers which have terminal plates connected through rectifiers to the opposite ends of the secondary windings thereof and center tap terminal plates extending from intermediate portions of the secondary windings.

There has been known a transformer apparatus having a pair of terminal plates connected through rectifiers to the opposite ends of the secondary winding of a transformer. The transformer apparatus of this design is mostly incorporated in a resistance welding system. More specifically, the first terminal plate is disposed on one side of the transformer and the second terminal plate is disposed on the other side of the transformer. These terminal plates are coupled to ends of first and second conductive bodies, respectively, the other ends of which are connected to the welding gun of the resistance welding system.

Resistance welding apparatus of the inverter type include switching devices, such as power transistors, on the primary side. Because of the capacity of these power transistors or the capacity of diodes on the secondary side, there is a certain limitation on a welding current that can

be supplied to the welding gun. In some applications which require a relatively large welding current to weld thick plates or plated steel plates, for example, it is desirable to connect a plurality of transformers for a higher welding current capacity.

To meet such a demand with the known transformer apparatus, the first terminal plates of the connected transformers have to be connected together at one end of the first conductive body, and the second terminal plates of the connected transformers have to be connected together at one end of the second conductive body, with the other ends of the first and second conductive bodies extending closely to each other and being connected to the welding gun. With this arrangement, however, the first and second conductive bodies project out of the transformers, and the transformers are spaced a distance which is required to connect the terminal plates to the first and second conductive bodies. As a result, the transformer apparatus is large and heavy as a whole. Therefore, the resistance welding apparatus incorporating the transformer apparatus is also large and heavy. It is difficult to install the large and heavy resistance welding apparatus on the arm of a robot or the like for automated welding operation.

Since the first and second conductive bodies to which the first and second terminal plates are connected are considerably long, they cause a substantial electric power

loss which makes it impossible to supply a large electric current efficiently to the welding gun.

The present invention provides a transformer apparatus comprising at least first and second transformer/rectifier assemblies each comprising a transformer including a secondary winding and a rectifier, a terminal plate connected to the secondary winding through the rectifier, a center tap terminal plate connected to an intermediate portion of the secondary winding, the terminal plate and the center tap terminal plate being disposed on one side of the transformer, the transformers of the first and second transformer/rectifier assemblies being disposed side by side, the terminal plates of the first and second transformer/rectifier assemblies being disposed closely to each other in confronting relation, and first and second conductive bodies interconnecting the terminal plates and the center tap terminal plates of the first and second transformer/rectifier assemblies.

Preferably, the first and second transformer/rectifier assemblies are symmetrically disposed.

Preferably,

the transformer further includes , third and fourth transformer/rectifier assemblies each comprising a transformer including a secondary winding, a rectifier, a terminal plate connected to the secondary winding through the rectifier, and a center tap terminal plate connected to an intermediate portion of the secondary winding, the terminal plate and the center tap terminal plate being disposed on one side of the transformer, the terminal plates and the center tap terminal plates of the first and second transformer/rectifier assemblies being connected to ends of the first and second conductive bodies, the terminal plates and the center tap terminal plates of the third and fourth transformer/rectifier assemblies being connected to the other ends of the first and second conductive bodies.

Preferably,

the transformer further includes a welding gun connected to the first and second conductive bodies.

The present invention also provides a transformer apparatus comprising at least two transformer/rectifier assemblies each comprising a transformer including a secondary winding and a rectifier, a terminal plate connected to the secondary winding through the rectifier, and a center tap terminal plate connected to an intermediate portion of the secondary winding, the terminal plate and the center tap terminal plate having attachments

for connecting the terminal plate and the center tap terminal plate to a welding gun.

Preferably, the terminal plate and the center tap terminal plate have connectors connected to the secondary coils of the transformer/rectifier assemblies, the attachments of the terminal plate and the center tap terminal plate being equally spaced from the connectors.

Preferably, the terminal plate has slits defined therein so that the terminal plate is flexible.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings, in which:-

FIG. 1 is a perspective view of a transformer apparatus with rectifiers according to a first embodiment of the present invention, the view also showing a welding gun installed on the transformer apparatus;

FIG. 2 is a front elevational view, partly in cross section, of the transformer apparatus;

FIG. 3 is a fragmentary side elevational view, partly in cross section, of the transformer apparatus;

FIG. 4 is an exploded perspective view of the transformer apparatus;

FIG. 5 is a circuit diagram of an electric circuit of the transformer apparatus;

FIG. 6 is a perspective view of a transformer apparatus with rectifiers according to a second embodiment of the present invention, the view also showing a welding gun installed on the transformer apparatus;

FIG. 7 is a front elevational view, partly in cross section, of the transformer apparatus;

FIG. 8 is an exploded perspective view of the transformer apparatus; and

FIG. 9 is a circuit diagram of an electric circuit of the transformer apparatus.

As shown in FIGS. 1 through 3, a transformer apparatus 10 with rectifiers according to a first embodiment of the present invention has a casing 12 of aluminum or the like defining four chambers 14a through 14d therein. The chambers 14a through 14d accommodate transformers 16a through 16d, respectively, of transformer/rectifier assemblies 15a through 15d.

The transformer/rectifier assembly 15a is constructed as follows:

The transformer 16a includes a pair of upper and lower cores 18a each in the shape of a hollow rectangular

parallelepiped. The upper and lower cores 18 accommodate a pair of secondary windings 22a each sandwiched between primary windings 20a. The primary windings 20a are connected to an AC power supply (not shown). Each of the secondary windings 22a has opposite ends 23a, i.e., starting and terminal ends, integrally connected to upper and lower secondary electrode plates 24a with an insulating member 26a disposed therebetween. Therefore, two winding ends 23a are connected to the upper secondary electrode plate 24a, and two winding ends 23a are connected to the lower secondary electrode plate 24a.

A terminal plate 30a is placed on rectifiers 28a which are held against the secondary electrode plates 24a remotely from the ends 23a of the secondary windings 22a. Disc springs 32a are disposed on the terminal plate 30a remotely from and in alignment with the rectifiers 28a, and a iron plate 34a is held against the disc springs 32a. The plate 34a, the terminal plate 30a, and the secondary electrode plates 24a are fastened together by bolts (not shown). The terminal plate 30a has a bent end projecting laterally out of the transformer 16a as a first connector 36a having a through hole 37a defined therein.

A center tap terminal plate 38a extends integrally from intermediate portions of the secondary windings 22a and has a bent end projecting laterally out of the transformer 16a as a second connector 40a parallel to the first connec-

tor 36a, the second connector 40a having a through hole 41a defined therein. In the transformer 16a, the first connector 36a serves as a positive electrode, whereas the second connector 40a as a negative electrode.

The other transformer/rectifier assemblies 15b through 15d are of the same construction as the transformer/rectifier assembly 15a described above. Those parts of the transformer/rectifier assemblies 15b through 15d which are identical to those of the transformer/rectifier assembly 15a are denoted by identical reference numerals with suffixes b, c, d, respectively, and will not be described in detail. The transformer/rectifier assemblies 15a, 15b are symmetrical in configuration and arranged side by side, and the transformer/rectifier assemblies 15c, 15d are also symmetrical in configuration and arranged side by side.

The first connectors 36a, 36b and the second connectors 40a, 40b of the transformer and rectifier combinations 15a, 15b are disposed closely and parallel to each other. Likewise, the first connectors 36c, 36d and the second connectors 40c, 40d of the transformer and rectifier combinations 15c, 15d are disposed closely and parallel to each other (see FIGS. 1 and 4).

A first conductive body 42 is joined to the first connectors 36a through 36d which serve as positive electrodes, and a second conductive body 44 is joined to the second connectors 40a through 40d which serve as negative

electrodes. As shown in FIG. 4, the first conductive body 42 is of a bent configuration composed of planar segments and has on one end a pair of supports 46a, 46b fitted between and fixed to the first connectors 36a, 36b and the first connectors 36c, 36d, respectively. The first conductive body 42 also has on its opposite end an attachment 48 directed at about 90° with respect to the supports 46a, 46b. The supports 46a, 46b have respective through holes 49a, 49b. The first conductive body 42 is fastened to the transformer assembly 10 by a bolt (not shown) inserted through the holes 37a, 37b in the first connectors 36a, 36b and the hole 49a in the support 46a and a bolt (not shown) inserted through the holes 37c, 37d in the first connectors 36c, 36d and the hole 49b in the support 46b.

The second conductive body 44 is of the same bent shape as the first conductive body 42, and has supports 50a, 50b fitted between and fixed to the second connectors 40a, 40b and the second connectors 40c, 40d and an attachment 52 corresponding to the attachment 48. The supports 50a, 50b have respective through holes 54a, 54b. The second conductive body 44 is also fastened to the transformer assembly 10 in the same manner as the first conductive body 42.

As shown in FIG. 1, a welding gun 60 is installed on the transformer apparatus 10. The welding gun 60 includes a bracket 62 secured to the casing 12, a fixed gun arm 64 attached to the bracket 62, and a movable gun arm 66

angularly movably supported on the bracket 62 and swingable with respect to the fixed gun arm 64 by a suitable opening/closing means such as a cylinder. The fixed and movable gun arms 64, 66 support respective electrodes 68a, 68b on confronting ends thereof. The fixed gun arm 64 and the attachment 48 of the first conductive body 42 are connected to the opposite ends of a multilayer copper web 70a, and the movable gun arm 66 and the attachment 52 of the second conductive body 44 are similarly connected to the opposite ends, respectively, of a multilayer copper web 70b.

The transformer apparatus 10 to which the welding gun 60 is attached is mounted on the arm 72 of a robot (not shown).

The transformer apparatus 10 and the welding gun 60 make up an electric circuit as shown in FIG. 5.

The transformer apparatus 10 according to the first embodiment is basically constructed as described above. Operation and advantages of the transformer apparatus 10 will now be described in detail below.

Two workpieces W_1 , W_2 are put together such that regions thereof to be welded to each other are superposed one on the other. The robot is actuated to cause the arm 72 to move the transformer apparatus 10 and the welding gun 60 toward the regions to be welded of the workpieces W_1 , W_2 . Then, the opening/closing means is operated to angularly move the movable gun arm 66 away from and toward the fixed

gun arm 62 to grip the workpieces W_1 , W_2 between the electrodes 68a, 68b on the gun arms 64, 66.

As shown in FIG. 5, a high-frequency alternating current which is produced by the non-illustrated AC power supply is transmitted from the primary windings 20a through 20d of the transformers 16a through 16d to the secondary windings 22a through 22d thereof. The alternating current is then rectified in a single-phase full-wave rectification mode by the rectifiers 28a through 28d connected to the ends of the secondary windings 22a through 22d. Therefore, rectified currents I_1 through I_4 flow from the connectors 36a through 36d of the terminal plates 30a through 30d to the first conductive body 42 which combines the supplied currents I_1 through I_4 into a welding current I_w . The welding current I_w is supplied from the electrode 68a electrically connected through the fixed gun arm 64 to the attachment 48 of the first conductive body 42 to the electrode 68b electrically connected through the movable gun arm 66 and the second conductive body 44 to the center tap terminal plates 38a through 38d. The superposed regions of the workpieces W_1 , W_2 are now fused and welded to each other.

With the first embodiment, the four transformer/rectifier assemblies 15a through 15d are disposed closely to each other, and the first and second conductive bodies 42, 44 are short, so that the transformer apparatus 10 is small and light as a whole.

More specifically, the first connector 36a of the terminal plate 30a connected through the rectifiers 28a to the opposite ends of the secondary windings 22a, and the second connector 40a of the center tap terminal plate 38a extending from the intermediate portions of the secondary windings 22a are positioned on one side of the transformer 16a of the transformer/rectifier assembly 15a. Similarly, the first connector 36b of the terminal plate 30b and the second connector 40b of the center tap terminal plate 38b are positioned on one side of the transformer 16b of the transformer/rectifier assembly 15b. The transformer/rectifier assemblies 15a, 15b are of a symmetrical configuration. With the transformer/rectifier assemblies 15a, 15b mounted in the casing 12 side by side, the first connectors 36a, 36b are disposed closely to each other in confronting relation, and the second connectors 40a, 40b are disposed closely to each other in confronting relation. The first connectors 36a, 36b and the second connectors 40a, 40b are spaced from each other by the distance corresponding to the thickness of the support 46a of the first conductive body 42 and the support 50a of the second conductive body 44. Thus, the transformer/rectifier assemblies 15a, 15b can be placed in a small space.

In the transformer/rectifier assemblies 15c, 15d, the first connectors 36c, 36d and the second connectors 40c, 40d are also spaced from each other by the distance corre-

responding to the thickness of the supports 46b, 50b of the first and second conductive bodies 42, 44. As a consequence, the four transformer/rectifier assemblies 15a through 15d can be placed in a small space, making the transformer apparatus 10 small in size.

Since the first connectors 36a through 36d and the second connectors 40a through 40d are positioned closely, the first and second conductive bodies 42, 44 are greatly reduced in overall length. As a result, the transformer apparatus 10 is light and small, and is not subject to a large electric power loss, so that it enables the welding gun 60 to weld the workpieces highly efficiently.

A transformer apparatus 100 with rectifiers according to a second embodiment of the present invention will be described below with reference to FIGS. 6 through 9.

Those components of the transformer apparatus 100 which are identical to those of the transformer apparatus 10 according to the first embodiment are denoted by identical reference numerals, and will not be described in detail.

As shown in FIGS. 7 and 8, a center tap terminal plate 102 which is fixed integrally to the transformers 16a through 16d is in the form of a plate and made of a conductive material. The center tap terminal plate 102 has connectors 104a through 104d extending radially outwardly from the center thereof. The connector 104a is of a zig-zag bent shape and secured to the intermediate portions of the second

secondary windings 22a of the transformer 16a. The other connectors are also of a zig-zag bent shape and secured to the intermediate portions of the secondary windings 22b, 22c, 22d, respectively. The center tap terminal plate 102 also has on its center an attachment 106 which is equally spaced from the radially outer connectors 104a through 104d. The attachment 106 extends in a direction perpendicular to the plane of the center tap terminal plate 102, and is bent upwardly (FIG. 8) at a right angle. The attachment 106 has threaded holes 108a, 108b defined in its outer end surface.

The pairs of rectifiers 28a, 28b, 28c, 28d are held against the pairs of secondary electrode plates 24a, 24b, 24c, 24d, respectively, and a terminal plate 110 is placed against the rectifiers 28a, 28b, 28c, 28d. The terminal plate 110 has rectangular connectors 112a, 112b, 112c, 112d extending radially outwardly center thereof, and an attachment 114 on the center. The attachment 114 has threaded holes 116a, 116b defined therein. Slits 118a, 118b are defined between the connectors 112a, 112b and between the connectors 112c, 112d.

Disc springs (not shown) are held against the connector 112a of the terminal plate 110 in alignment with the rectifiers 28a, respectively. The plate 34a, the connector 112a, and the secondary electrode plates 24a are fastened together by bolts 120a (FIG. 6). Likewise, the plates 34b, 34c, 34d, the connectors 112b, 112c, 112d, and the secondary

electrode plates 24b, 24c, 24d are fastened together by bolts 120b, 120c, 120d, with the rectifiers and disc springs interposed therebetween. Since the terminal plate 110 has the slits 118a, 118b, the terminal plate 110 is relatively flexible to allow its connectors 112a through 112d to be fixed securely to the secondary electrode plates 24a through 24d.

The opposite ends of the multilayer copper web 70a are connected by bolts to the fixed gun arm 64 of the welding gun 60 and the attachment 106 of the center tap terminal plate 102. Likewise, the opposite ends of the multilayer copper web 70b are connected by bolts to the movable gun arm 66 and the attachment 114 of the terminal plate 110.

FIG. 9 shows an electric circuit provided by the transformer apparatus 100 and the welding gun 60.

The transformer apparatus 100 according to the second embodiment operates in substantially the same manner as the transformer apparatus 10 according to the first embodiment. More specifically, as illustrated in FIG. 9, rectified currents I_1 through I_4 flow from the connectors 112a through 112d of the terminal plate 110 flow to the attachment 114 which combines the supplied currents I_1 through I_4 into a welding current I_w . The welding current I_w is supplied from the electrode 68a electrically connected through the fixed gun arm 64 to the attachment 114 to the electrode 68b electrically connected through the movable

gun arm 66 to the center tap terminal plate 102. Since the attachment 114 is positioned at the center of the terminal plate 110, the currents I_1 through I_4 rectified by the rectifiers 28a through 28d are accurately combined to produce the welding current I_w . The superposed regions of the workpieces W_1 , W_2 are now fused and welded to each other.

With the second embodiment, the number of parts used in combination with the four transformer/rectifier assemblies 15a through 15d housed in the casing 12 is greatly reduced, making the transformer apparatus 100 smaller in size and minimizing any electric power loss caused by the transformer apparatus 100.

More specifically, the connectors 104a through 104d of the center tap terminal plate 102 are secured to the intermediate portions of the secondary windings 22a through 22d of the transformer/rectifier assemblies 15a through 15d, and the fixed gun arm 64 is directly coupled to the attachment 106 of the center tap terminal plate 102 through the multilayer copper web 70a. The connectors 112a through 112d of the terminal plate 110 are connected to the opposite ends of the secondary windings 22a through 22d through the rectifiers 28a through 28d, and the movable gun arm 66 is directly coupled to the attachment 114 of the terminal plate 110 through the multilayer copper web 70b.

Accordingly, the number of parts connected to the transformer/rectifier assemblies 15a through 15d is reduced,

and no considerably long conductive bodies are required in connecting the transformer/rectifier assemblies 15a through 15d. The transformer apparatus 100 is therefore reduced in size and weight. Any electric power loss caused by the transformer apparatus 100 is greatly reduced, making it possible to enable the welding gun 60 to weld the workpieces efficiently.

The attachment 106 projecting from the center of the center tap terminal plate 102 allows the current to flow from the electrode 68b through the attachment 106 uniformly to the connectors 104a through 104d.

With the present invention, as described above, at least two transformer/rectifier assemblies are disposed closely to each other, so that the transformer apparatus is small in size. The conductive bodies which interconnect the terminal plates of the transformer/rectifier assemblies and the center tap terminal plates are reduced in length. As a result, the transformer apparatus is also small in weight, and the electric power loss caused thereby is considerably reduced.

Moreover, the number of parts used in combination with the transformer/rectifier assemblies is reduced, also reducing the weight of the transformer apparatus and the electric power loss caused thereby.

The preferred embodiments of the present invention can provide a transformer apparatus which is smaller and lighter than those of the prior art and can minimize an electric power loss to supply a welding current efficiently.

Although certain preferred embodiments have been shown and described, it should be understood that many changes and modifications may be made therein without departing from the scope of the appended claims.

CLAIMS.

1. A transformer apparatus comprising:
 - at least first and second transformer/rectifier assemblies each comprising a transformer including a secondary winding and a rectifier;
 - a terminal plate connected to said secondary winding through said rectifier;
 - a center tap terminal plate connected to an intermediate portion of said secondary winding, said terminal plate and said center tap terminal plate being disposed on one side of the transformer;
 - the transformers of said first and second transformer/rectifier assemblies being disposed side by side, the terminal plates of said first and second transformer/rectifier assemblies being disposed closely to each other in confronting relation; and
 - first and second conductive bodies interconnecting said terminal plates and the center tap terminal plates of said first and second transformer/rectifier assemblies.
2. A transformer apparatus according to claim 1, wherein said first and second transformer/rectifier assemblies are symmetrically disposed.
3. A transformer apparatus according to claim 1 or 2, further including third and fourth transformer/rectifier assemblies each comprising a transformer including a secondary winding, a rectifier, a terminal plate connected to

said secondary winding through said rectifier, and a center tap terminal plate connected to an intermediate portion of said secondary winding, said terminal plate and said center tap terminal plate being disposed on one side of the transformer, the terminal plates and the center tap terminal plates of said first and second transformer/rectifier assemblies being connected to ends of said first and second conductive bodies, the terminal plates and the center tap terminal plates of said third and fourth transformer/rectifier assemblies being connected to the other ends of said first and second conductive bodies.

4. A transformer apparatus according to claim 1 or 3, further including a welding gun connected to said first and second conductive bodies.

5. A transformer apparatus comprising:

at least two transformer/rectifier assemblies each comprising a transformer including a secondary winding and a rectifier;

a terminal plate connected to said secondary winding through said rectifier;

a center tap terminal plate connected to an intermediate portion of said secondary winding; and

said terminal plate and said center tap terminal plate having attachments for connecting said terminal plate and said center tap terminal plate to a welding gun.

6. A transformer apparatus according to claim 5, wherein said terminal plate and said center tap terminal

plate have connectors connected to the secondary coils of said transformer/rectifier assemblies, said attachments of said terminal plate and said center tap terminal plate being equally spaced from said connectors.

7. A transformer apparatus according to claim 5 or 6, wherein said terminal plate has slits defined therein so that the terminal plate is flexible.

8. A transformer apparatus substantially as hereinbefore described with reference to Figs. 1 to 5 or Figs. 6 to 9 of the accompanying drawings.

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